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ABSTRACT

The research process has been a constant feature of the curriculum in primary and secondary schools for many years. The purpose of this process has traditionally been to develop student research skills and to enhance their knowledge within a particular area. The Information Process diagram, developed by the Australian School Library Association in conjunction with the Curriculum Corporation, places the research process within the context of generic learning skills. The advent of the digital information era has challenged and changed many of the traditional research sources, tools, practices and the premises on which they operate, though the essential process still depends on critical thinking, problem solving, and communicating. The digital information environment is dynamic; multimedia sources combine several media such as text, graphics, animation, audio, and video in an integrated format which is accessed by computer. Related technologies are having an impact on Australian education, for example. Digital cameras, notebook computers, and other devices have aided secondary students in recording observations during an expedition to the Snowy River. Primary students have also used educational technology to enhance information gathering at a trip to a botanic garden. Students can create personalized "knowledge webs," with their assignments hyperlinked to each other and to Internet resources. Each new resource format requires the development of new skills or extensions of old ones to enhance student learning. Students must become competent researchers and information managers with a well-developed capacity to critically evaluate information for accuracy, relevance, and usefulness as well as to search and manage huge quantities of information available through the Internet and other electronic sources. Information literacy within a digital environment uses many of the information skills already identified in the literature, but new skills must be taught if the potential of a digital world is to be exploited. The digital environment has allowed students and teachers to become part of a global research community that is premised on information sharing and individual and collective discovery. (Contains 10 references.) (Author/SWC)

Approaches to research in a digital environment — Who are the new researchers?

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The research process in all its different configurations — assignments, independent work requirements — has been a constant feature of the curriculum in primary and secondary schools for many years. The purpose of this process has traditionally been to develop student research skills and to enhance their knowledge within a particular area; although it would have to be admitted that it has been used by many as a time filler rather than a teaching strategy directed towards specific learning outcomes.

Academics have devised numerous configurations of this research process (Marland, 1981; Irving, 1982; Kulthau, 1985; Ministry of Education, Victoria, 1989; Gawith, 1988; Wilson, 1989). However the essential components of the process are identified in the literature as: pre-research, location of resources, selection of resources, recording relevant information, analysing the information, synthesising the information, presenting the results in an appropriate format and evaluating the result and the process.

The Information Process diagram devised by the Australian School Library Association in conjunction with the Curriculum Corporation places this process within the context of generic learning skills and is a useful improvement on many of the other models.

The resource bank which students have used to support research tasks have traditionally relied very heavily on print materials, particularly books and journals. These resources have generally been accessed via school or local libraries. Whilst other sources like video, maps and people have also been valued, print based sources have been the predominate resource format. Traditional research tools like abstracts and indexes have been integral to the efficient location of relevant material.

Research in a digital environment

The advent of the digital information era has challenged and changed many of the traditional research sources, tools, practices and the premises on which they operate. Though it must be said at the outset that the research process as identified in the information process diagram is intrinsically the same. It is still about critical thinking, problem solving and communicating. The diverse range of new information and communication technologies has provided new information sources, hitherto inaccessible. These technologies have provided different ways of accessing that information as well as different ways of organising and presenting work.

The digital information environment is dynamic. Multimedia sources combine several media such as text, graphics, animation, audio and video in an integrated format which is accessed by computer. Multimedia is being heralded as one of the most important influences on schooling for the next millennium. The Internet, in particular the World Wide Web and CD Rom programs as well as

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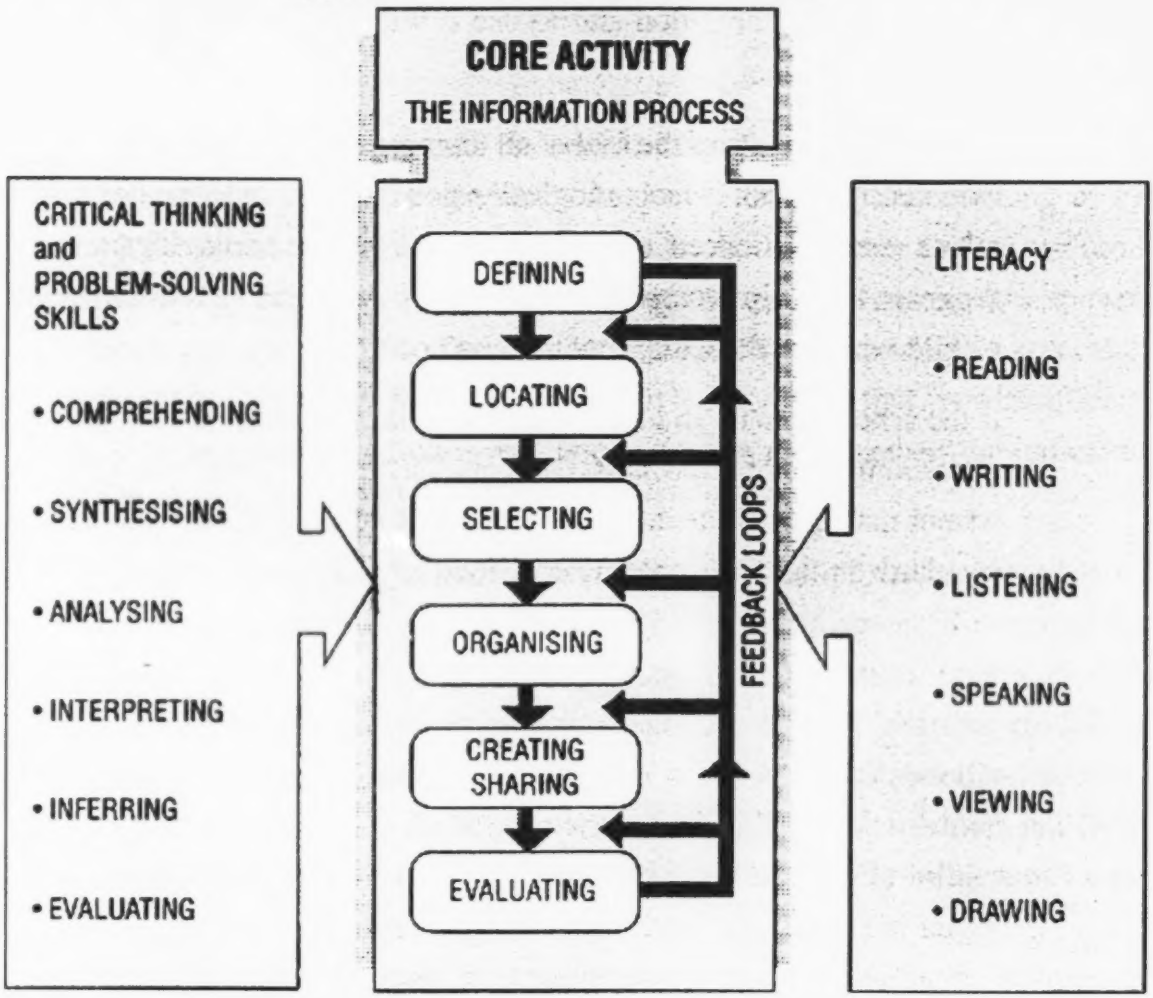
other disk based packages are already having an impact on curriculum design, teaching and learning strategies and activities, library collections and the physical infrastructure of schools.

Appendix 1: The Information Process



Multimedia resources provide access to vast quantities of information in a form that is often more easily retrieved. The CD Rom format for example, can provide an active, in depth reference source on specialised topics or themes. Its features of accessibility, portability and effective storage supplants several weighty tomes on the same topic. The application of the CD ranges from the storage of complex definitive static databases as found in Year Books, dictionaries and encyclopaedias to highly interactive investigative processes used for teaching surgical techniques and fields limited only by one's imagination.

So too, the Internet is already offering significant opportunities for the enhancement of student learning. Students are communicating via email with their peers from around the world. The Global penpal and Art experiences are those which can breathe new life into the concept of writing for communication and ideas sharing. The cultural breadth encouraged through these exchanges do much to allow our students to understand the differences and similarities of people wherever they are. Students are taking part in global or regionally based collaborative research projects. They can go on Internet hunts or get information on the latest film reviews from across the globe. They are visiting online exhibitions, gathering material and images from museums, libraries and databases and importantly they are sharing their ideas and work through electronic publishing.

Negroponte identified significant advantages of digital information in the form of email over voice or snail mail communication. "The true advantage of electronic mail is the ability to process the information you get. You can forward pieces. You can use sections of incoming messages in your outgoing communications. You can store it and retrieve it at will. In short, it has all the advantages of being digital." (Shulman, 1996) Further, electronic communication breaks down the barriers of time, location and social standing between people. Intellectual hierarchies, once a barrier to learning and the exchange of ideas are being dissolved by an overpowering sense of curiosity generated by a digital landscape of instant information. Scientists have always sought to exchange information with other research colleagues. This was done most often via printed journals and conference presentations. Email provides a more direct and immediate opportunity for discourse not only with colleagues but with teachers, schools students or members of community groups thus enriching the exchange and learning of all.

The tools and resources on the Internet offer the opportunity for interaction in a manner and variety never before experienced. The Collaboratory for Research on Electronic Work *(http://www.crew.umich.edu/AboutCREW.html)* investigates how new technologies enable new ways of organising work. It is an example of what it studies: "a Collaboratory," a distributed organisation made possible by new technologies." From a range of locations CREW members share common facilities that support group work, distributed in time or place but which allow them to conduct joint research. Their contribution to the collaboratory approach is via a mixture of laboratory studies, field observation and engagement in design of new systems and work arrangements.

Schools and Research

Similar approaches incorporating students and schools in the generation of high quality research data are now emerging in the K-12 sector. Relatively low cost access to the Internet, information systems and new technologies place students at the front line of educational opportunity, research and involvement; in many cases they are significantly ahead of industry, commerce and their teachers. The following examples illustrate where we are placed on the continuum of innovation and learning and the exciting challenges we face as educators.

In April 1996 ANZSES, the Australian and New Zealand Scientific Exploration Society, working in partnership with the DSE and private enterprise, conducted a scientific research expedition for senior secondary students to a remote part of the Snowy river. The expedition focus was on small mammal and flora research, recording observations using digital cameras, notebook computers and experimenting with satellite communication links to tertiary institutes and websites. The students were able to be engaged in primary scientific research , under the supervision of scientists and Natural Resources and the Environment(NRE) rangers trialing and evaluating the very latest technologies, safe in the knowledge that their 'satellite in a suitcase' link provided their true global position for all to see. The students were able to locate and identify new species, accepting and rejecting hypotheses and establishing permanent record in photographic and digital form. Their work has been recorded and presented in Photo-CD form.

Research activities of this type stimulate enormous interest in 'what is possible' under difficult and challenging conditions; testing not only the suitability of technology but the practicality of using students for species research. ANZSES and the Department of Natural Resources and the Environment will gain valuable information about this type of research which may then be applied to alpine and coastal parks and popular environmentally sensitive locations such as the Grampians, Wilsons Promontory and the Little Desert.

The Internet and other digital technologies are providing children with both the media and mechanisms to explore, investigate and replicate studies beyond traditional geographic boundaries. Email, closed discussion groups and Internet chat are no longer the province of academics or departments interested in national defence; they are accessed by children who operate without fear of computers and skilled in the world of electronic toys and games.

To apply the knowledge and skills of play to education is quite normal for children and software designers have not been slow to exploit this path. To incorporate education programs and content into games is the logical commercial next step and one which will almost guarantee that software designers control both markets. The dangers in this scenario are obvious and should be cause for real

concern amongst those associated with education. Issues such as control of information and educational services through fee for service and other forms of restricted access have been a source of keen debate and should be resolved. Schools are conscious of the costs associated with Internet and email and access to CD technology, and the major carriers of digital, cable and satellite services expect to profit from these businesses. So where does this user-pay system leave children? Part of the answer lies in directing education away from commercial products and towards involving children in areas of creative original work and primary research.

The concept of engaging very young primary school students in original field work is being considered by the Royal Botanic Gardens and Department of Natural Resources and the Environment, who plan to verify existing databases and create new data related products such as the first atlas of fungi in Australia. An on-going student project can replicate existing research, trial the suitability of digital camera use and the development of software for collecting managing and analysing species data and displaying this location data on an active screen. Not only does this type of activity provide low cost verification of important research but it engages children in the application of technologies and methodologies hitherto unknown and exposes them to pure research. But there are costs with such projects and they will not proceed without funding and a significant time commitment from experts.

Interactive CDs currently under development and evaluation provide students with opportunities to 'walk' through a virtual heathland, wetland or desert, investigating species, topography, soil type, rainfall and eco-relationships; being able to change the parameters and explore consequences. This technology is already being applied to libraries, museums, galleries and inaccessible geographic locations. Simulations based on definitive high integrity databases exist within the convenient form of the CD and these have been made accessible to all age groups through clever writing which preserves data integrity. The opportunity to alter parameters and interact with the CD creates a digital 'research' environment which is limited only by the integrity of the data and the skill of the programmer.

There are important rare databases relating to all disciplines which are inaccessible to all but a handful of curators and scientists. Digitising these data represents the first significant step to freeing information access to new audiences and on a scale not previously contemplated.

The design, construction and sailing of a boat in the Whitbread Around the World yacht race may seem a meaningless and idle pursuit to many, but it provides studies of materials technology, psychology and nutrition, the development of navigation aids and the opportunity to study ornithology, oceanography and weather. To be able to access all stages of this venture though the use of digital cameras, the Internet and on-line student projects provides a new dimension to the traditional classroom and a generic classroom model independent of location. How better to introduce young children to global information and positioning systems and location co-ordinates, and older students to the complexities of mathematical modelling than through a navigation competition which tracks a sailing boat for over 40,000km. Is this the new research — using primary data and free from commercial influence, and being done by students?

There are those who question embracing of a digital world as a passing fad, but using a motor industry analogy, it would be safer to argue that we are at the model-T end of a digital information and communication era which is being driven by the creative imagination and perceived needs of all age groups. Students need education relevant to the times in which they live and a future which we second guess, but it must be free from commercial control. Business needs digital information and communication technologies to increase efficiencies and reduce costs. Special interest groups including the disabled and the elderly need Internet connected mobile phones, notebook computers, on-line services and email more than most just for basic equity and quality of life reasons. Children need access to the definitive data bases of the Australian Bureau of Statistics, libraries, museums and other government departments. Who better to be involved in the selection of interesting educational databases than children working with educators? Who better to have access to and involvement in projects related to waste management and research on ocean and bay litter than children; the future minders of the planet? Who better to investigate the river systems, salination, water quality and ozone levels than children? What better way to learn about the Australian Stock Exchange, wealth and job creation and the securities industry than by playing the ASX Sharemarket Game on-line. It will be through education projects that we will learn to value historic buildings, marine heritage, air and space history and each other; and on-line projects will facilitate the process and give ownership to

those with the need to know. It will be through classroom simulations and quasi-experimental research of things happening now that children will understand the messages of organisations like Sunsmart and QUIT, and the National Heart and Asthma Foundations; learning how to establish ownership and a global view. The value of education sites on the Web cannot be understated in this area of endeavour. The collection of these sites and interactive projects in one location as occurs in the Directorate of Schools Education website, SOFWeb (http://www.dse.vic.gov.au) provides an efficient way of initiating, guiding and publishing student research.

The Creation of Individual Knowledge Webs

The Information Age also offers another perhaps more powerful learning opportunity. It provides the tools to challenge the compartmentalised view of learning which is so often exhibited in the school classroom by the " research project". For the first time students are realistically able to gather, store and retrieve information that they have constructed over a period of years. Students have access to and are expected to use a diverse range of information sources to support their research tasks — books, video, people, maps, statistics, CDRom, on-line information via the Internet. Using information technology and database programs they can store and retrieve not only the final essay, project or product but notes taken electronically, references to useful resources and dynamic links to internet resources. They can create an individual knowledge web which links information stored in a series of files using keywords and hypertext links. A knowledge web is consequently not defined only by information gathered for a particular task but by student interest and student discovery. This reinforces the relatedness of information rather than compartmentalising it. Updating and expanding an individual knowledge web defines learning as an ongoing experience.

The management of students' knowledge webs requires specific guidance in the establishment, maintenance and management of personal databases of information as well as electronic notetaking, keyword searching and the basic categorising of information. However computer technology offers the chance to manage this efficiently and without the dilemmas of storage and retrieval which characterises current practices. Even more importantly it encourages students to value the process and products of their own learning over time.

Issues for Educators

This dynamic digital environment is not without its problems. In terms of the Internet, the search for valuable and reliable sources of information is of prime concern. The search engines, to date, are limited by the uncontrolled standards of information placed on the Web and the search parameters of the search engines. Therefore keyword searching can still be a very hit and miss affair using expensive resources of personal and charged time. The development of sophisticated archiving and indexing systems and clever search engine software is needed as the size and complexity of the Internet grows, but the nature of the Web almost guarantees that the users, especially students will be constantly challenged by features which, by any measure, are unfriendly.

The print based publishing world has by default through its high cost structure limited the number of people who could have their work published. Therefore the credentials, accuracy and quality of authors gave users at least an initial, if somewhat dubious, filtering process. However, in cyberspace where there is access to low cost publishing, users are faced with a very different landscape. They must acquire highly developed information literacy skills. Esther Grassian, UCLA College library has focused on this issue in her paper " Thinking Critically about World Wide Web Resources"

(URL — http://www.ucla.edu.edu/campus/computing/bruinonline/trainers/critical .html)
Grassian identified several key elements requiring evaluation in the on-line, hypertext world of the Web — Content and Evaluation; Source and Date; Structure; Interactivity and Security. Of particular concern is the ability to identify the author or producer information on the Internet . The World Wide Web allows virtually anyone to be a publisher. The expertise, credentials, reputation and philosophy are often not disclosed and so it is difficult to attribute value or worth to the information. For those without effective evaluative skills, the work of an expert can be placed alongside that of an interested amateur with an opinion, and afforded equal weight.

Related to this is the security of the data on the World Wide Web. Information provided by an expert can be corrupted by the interested amateur or another expert unless effective protection is established by the original author. This confuses the whole issue of assigning ownership or measuring value and authenticity.

The same level of vigilance is required when evaluating CD ROM materials. Commercially produced CD ROM resources have improved significantly in design and quality of information over the last five years. However, there is still the predisposition to view any multimedia resource as valuable. The premise being that if research information is digital, coloured, has hypertext links with video or animation and displayed on a VDU screen it must be useful. In the early nineties there were many examples of poorly designed CD ROM based packages which had little educational value and certainly did not provide better learning experiences than those using conventional sources. CD ROM resources require levels of critical examination similar to that of online resources from the Internet.

Conclusion

Despite these words of caution it is clear that many of the factors which limited students learning experiences through research projects, to either local exploration or second hand viewing via secondary resources, are overcome when using electronic resources to locate, gather, organise, present and publish.

Each new resource format requires the development of new skills or extensions of old ones to enhance student learning. To make the Internet work within a learning context requires careful preparation. The focus on the development of information literacy skills that equip students with skills and strategies to search and manage the huge information reservoir of the Internet is crucial. Students must become competent researchers and information managers with a well-developed capacity to critically evaluate information for accuracy, relevance and usefulness. These skills have been taught previously with reasonable success within the context of static information sources, using a resource base that was generally defined and organised. The Internet is not organised, defined or static. The dynamic nature and uncontrolled growth of the Internet means that skills which enable students to exploit its potential must be consciously developed. The research process outlined earlier in this paper provides a thinking and strategic framework for the development of these skills. Information literacy within a digital environment uses many of the information skills already identified in the literature. However new skills must be taught if the potential of a digital world is to be exploited.

So who are the new researchers? We would argue that the digital environment has allowed students and teachers to become part of a global research community. This community is one which is premised on information sharing and individual and collective discovery. It requires new skills and new strategies but also builds on old ones. One of the key outcomes of the educative process delivered within a school context is the development of independent, information literate individuals. The research project has traditionally been the teaching approach used to support this outcome. Information and communication technologies underscore the need for information literacy skills but also provide in part the information resources and tools to achieve this outcome.

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